Flat bands, scanning tunneling microscopy, and the violation of time-reversal symmetry

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The topological fermion condensation of quantum phase transition (FCQPT) paves a new avenue in modern physics. Such a transition belongs to the unique type of quantum phase transitions the originators of the theory of instabilities omitted, and leads to the topological reconstruction of the Fermi surface. We discuss the modification of the systems under the action of FCQPT, representing the "missed" instability, which allows the development of an entirely new approach to or a "second edition" of condensed matter theory, presenting this physics as a completely new method for studying many-body objects.

Tunneling differential conductivity (or resistivity) is a sensitive tool to experimentally test the non-Fermi liquid (NFL) behavior of strongly correlated Fermi systems. In the case of common metals the Landau Fermi liquid (LFL) theory demonstrates that the differential conductivity is a symmetric function of bias voltage V. This is because the particle-hole symmetry is conserved in LFL state. When a strongly correlated Fermi system turns out to be near the topological fermion condensation quantum phase transition, its LFL properties disappear so that the particle-hole symmetry breaks making the differential tunneling conductivity to be asymmetric function of V. This asymmetry can be observed when a strongly correlated metal is in its normal, superconducting or pseudogap states. We show that the asymmetric part of the dynamic conductance does not depend on temperature provided that the metal is in its superconducting or pseudogap states. In normal state the asymmetric part diminishes at rising temperatures. Under the application of magnetic field the metal transits to the LFL state and the differential tunneling conductivity becomes a symmetric function of V. These findings are in good agreement with recent experimental observations.

We argue that existing theories based either on model calculations within Hubbard and Kondo models simulations, based actually on the more complicated versions of the same models, were not able to explain the destruction of asymmetric conductivity in sufficiently high magnetic fields. To the best of our knowledge, the presented FC theory is the only one capable to explain the above experimental puzzles. Moreover, our approach suggests that FCQPT is intrinsic to strongly correlated substances and can be viewed as the universal cause of their NFL behavior.

1. V.R. Shaginyan, A.Z. Msezane, G.S. Japaridze, V.A. Stephanovich, Y.S. Leevik, *JETP Lett*. **108**, 335 (2018).